Validation of FDS Predictions on Fire-Induced Flow: A Follow-up to Previous Study

Lei Wang, China Univ. of Mining and Technology
Johnson Lim, Defence Science & Technology Agency, Singapore
James G. Quintiere, Univ. of Maryland

Contents

1 Motivation

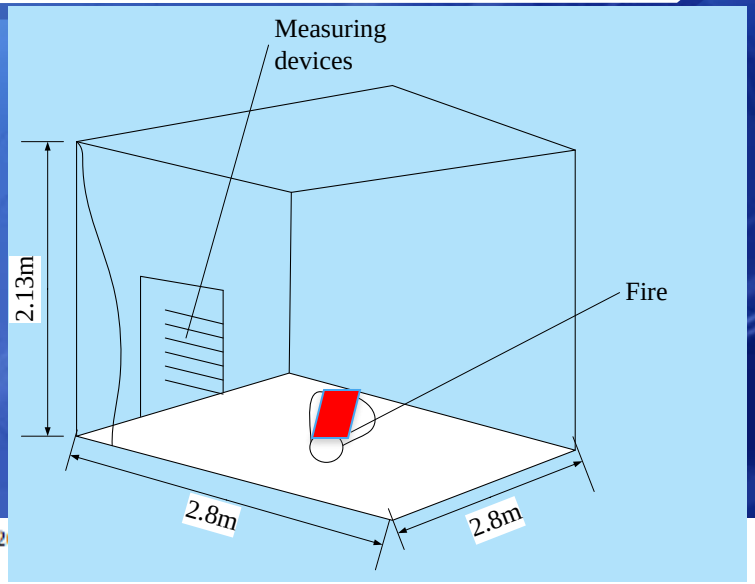
2 Approach

3 Results

4 Discussion

Motivation

- In an earlier study, Steckler's experiments were modeled using FDS, a zone model & correlation



Fire Safety Journal 44 (2

Contents lists available at ScienceDirect

Fire Safety Journal

journal homepage: www.elsevier.com/locate/firesaf

ELSEVIER

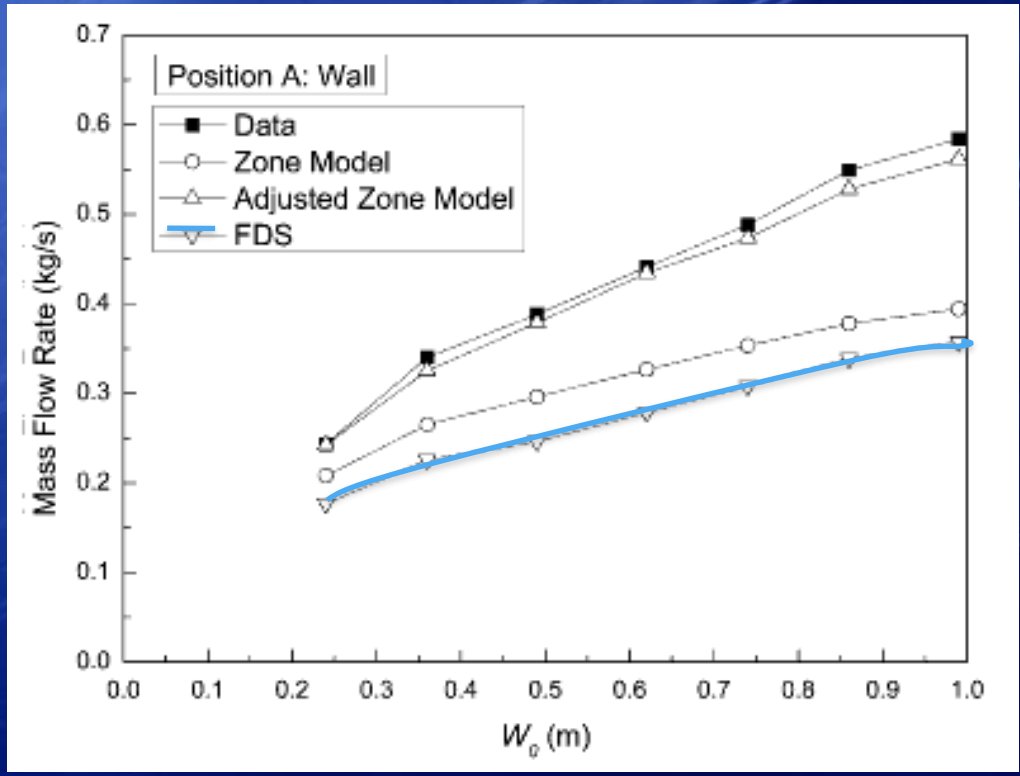
An analysis of compartment fire doorway flows

Lei Wang [a], James G. Quintiere [b,*]

[a] China University of Mining and Technology, PR China
[b] University of Maryland, MD 20742-3031, USA

Motivation

- It was found that the FDS model lacked the ability to accurately predict the flow rate
- & and other aspects:
  - Neutral plane
  - Layer height
  - Lower Temperature.
- 50 % discrepancy in flow.
- The current work attempts to improve the FDS results.



Motivation

Previous FDS

- FDS v5.1.0
- 5 cells across the face of the 30 cm burner
- Vent boundary condition
  - Outflow dynamic pressure = 0
  - But from Bernoulli:

New FDS

- A little finer grid
- Boundary extended beyond the vent
- Adjustment for burner shape against wall
  - Square vs round

Approach

Finer resolution

$$D^* / \delta x = 5.3$$

$$D^* / \delta x = 6.3$$

Approach

- The same grid size (uniform 5 cm) is used in the FDS validation by NIST for the prediction of the hot gas layer temperature and velocity profile at the doorway based on the same Steckler's experiments.
- An additional simulation with a smaller grid of 2.5 cm revealed that the difference between the results for the two grid sizes is negligible. Thus, the gird size of 5 cm is regarded as grid independent.

Approach

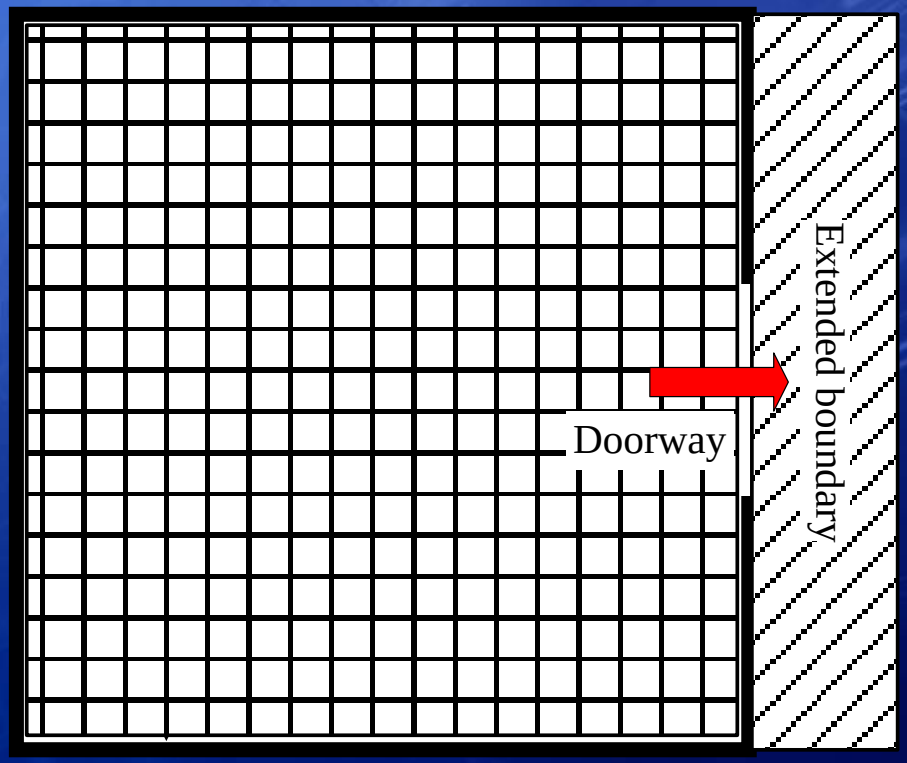
Radiative fraction

Default 0.35 for LES in FDS

Updated 0.14 based on Tewarson's data for methane

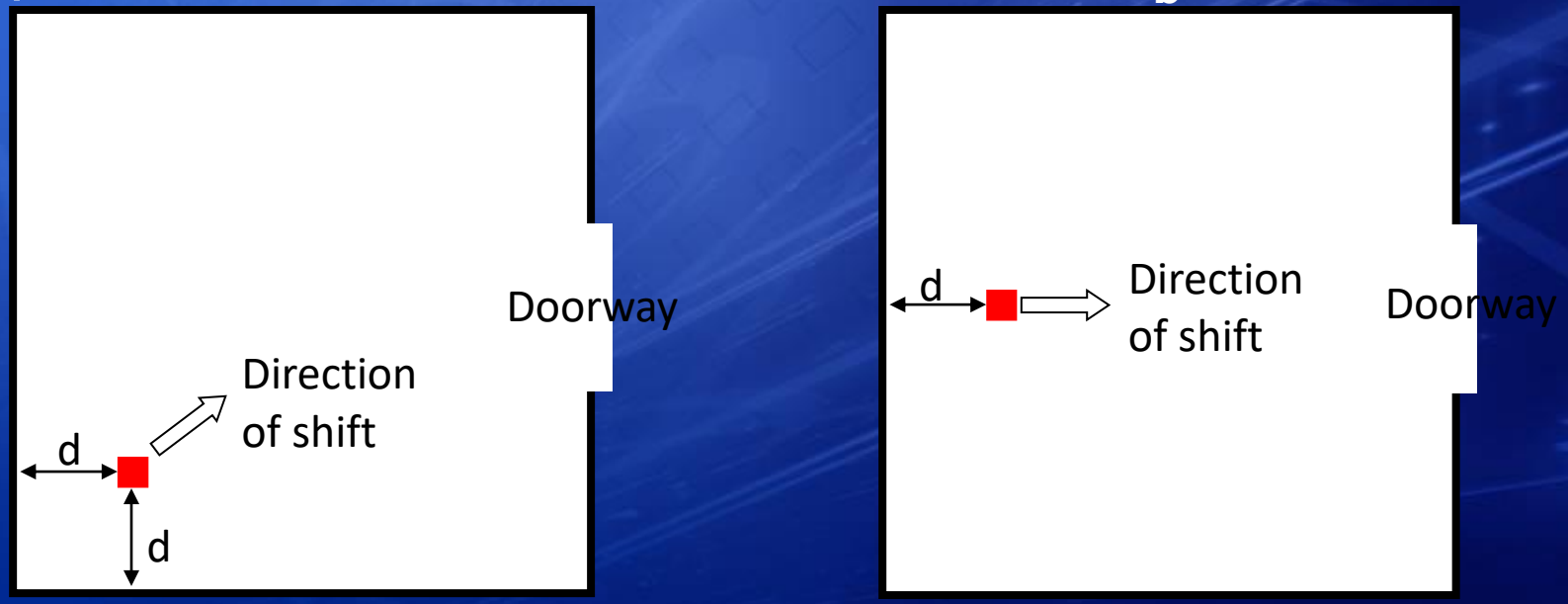
Approach

- An extension of computational domain.
- The distance that the domain was increased was scaled to the effective diameter, D_d of the doorway.**Used 0.5 D_d** (to get flow rate to 5%)



Approach

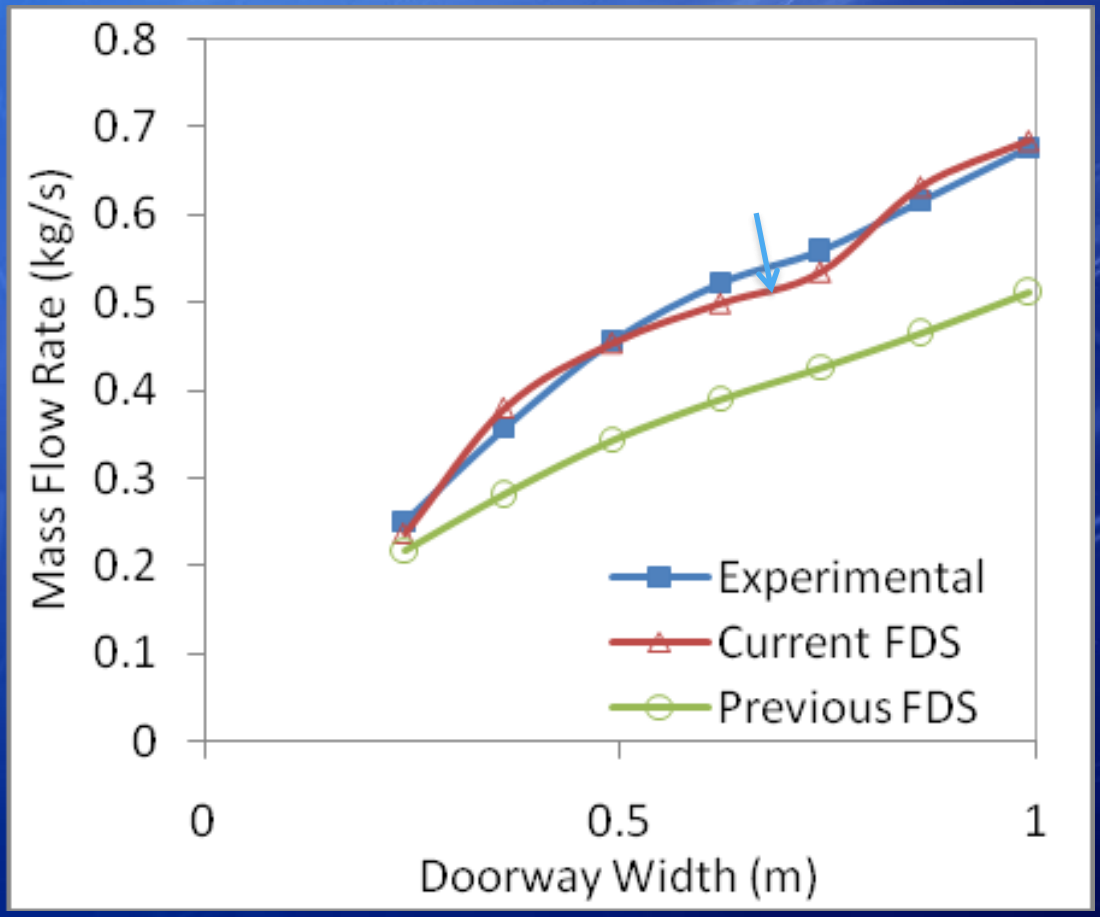
- A shift of fire location to account for the lost entrainment by the square fire used in FDS. The distance is also scaled to the burner diameter, $D_{b,}$ in an attempt to investigate possible correlations. **Used $d=\sim 2D_b$**



Shift of fire locations for position B (corner) and C (against wall).

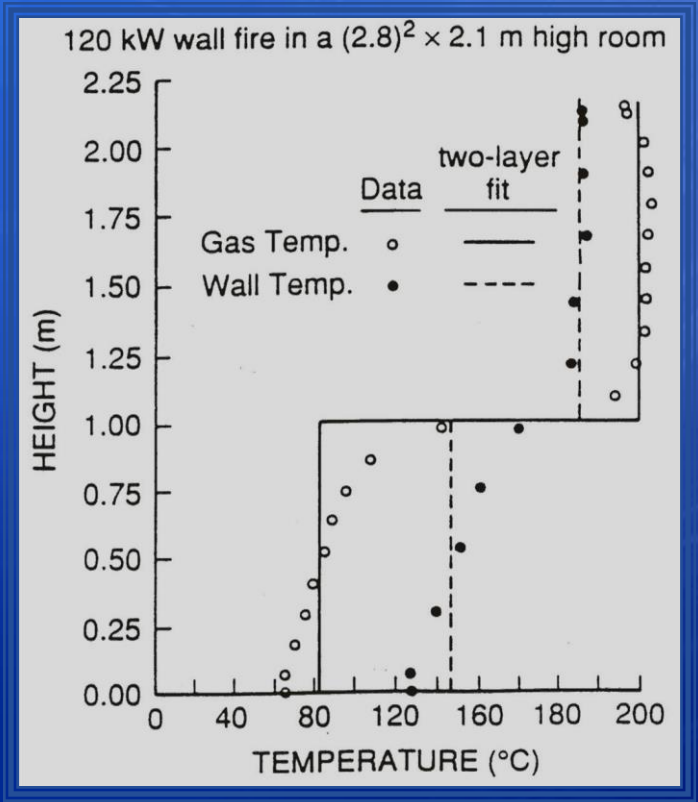
Results

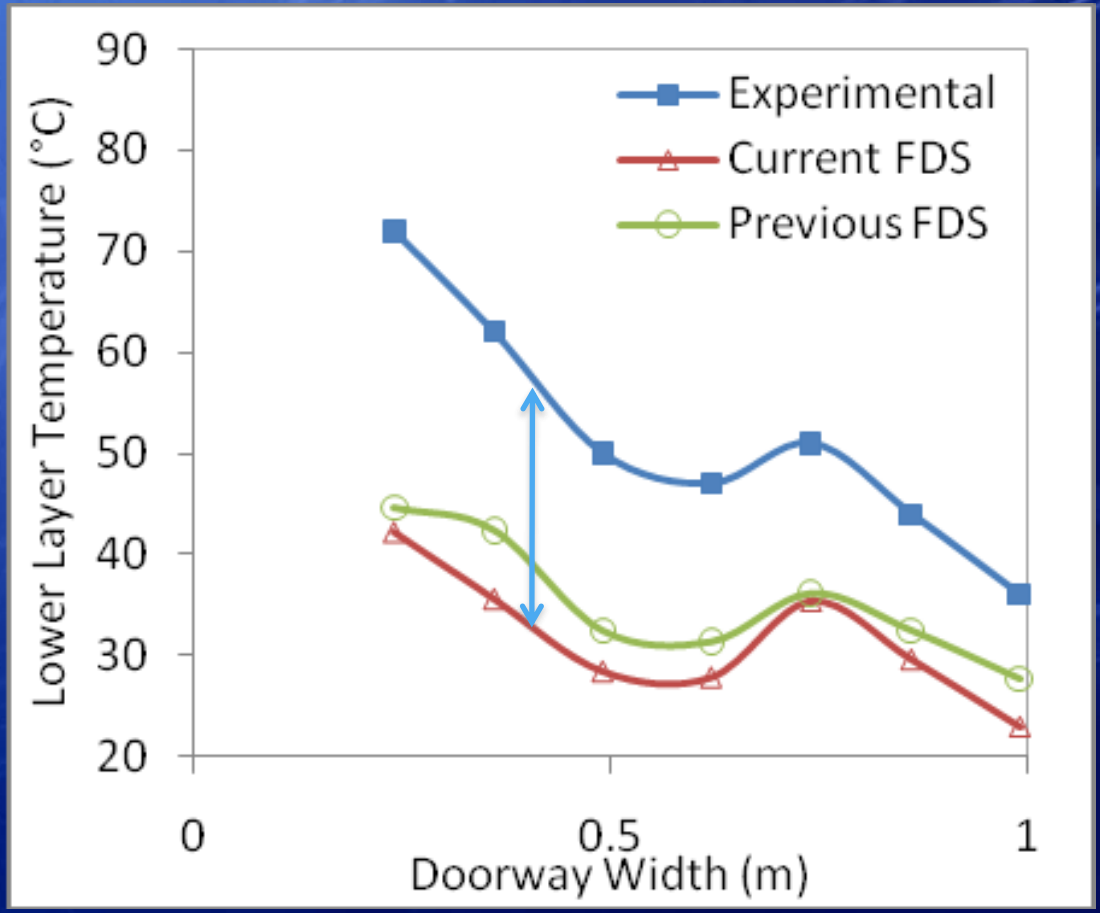
- Fire Source at Center (Position A) :Mass flow rate



Results

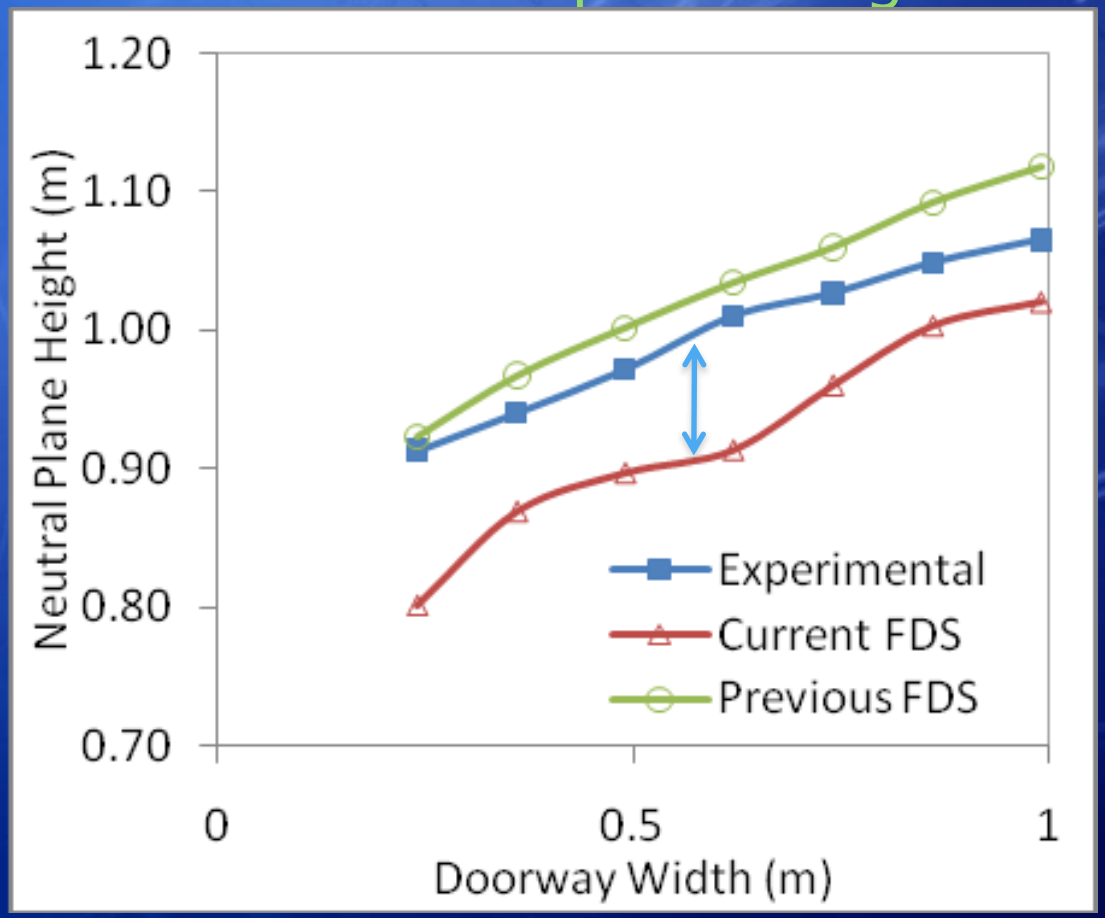
- Fire Source at Center (Position A):
  - Lower layer temperature





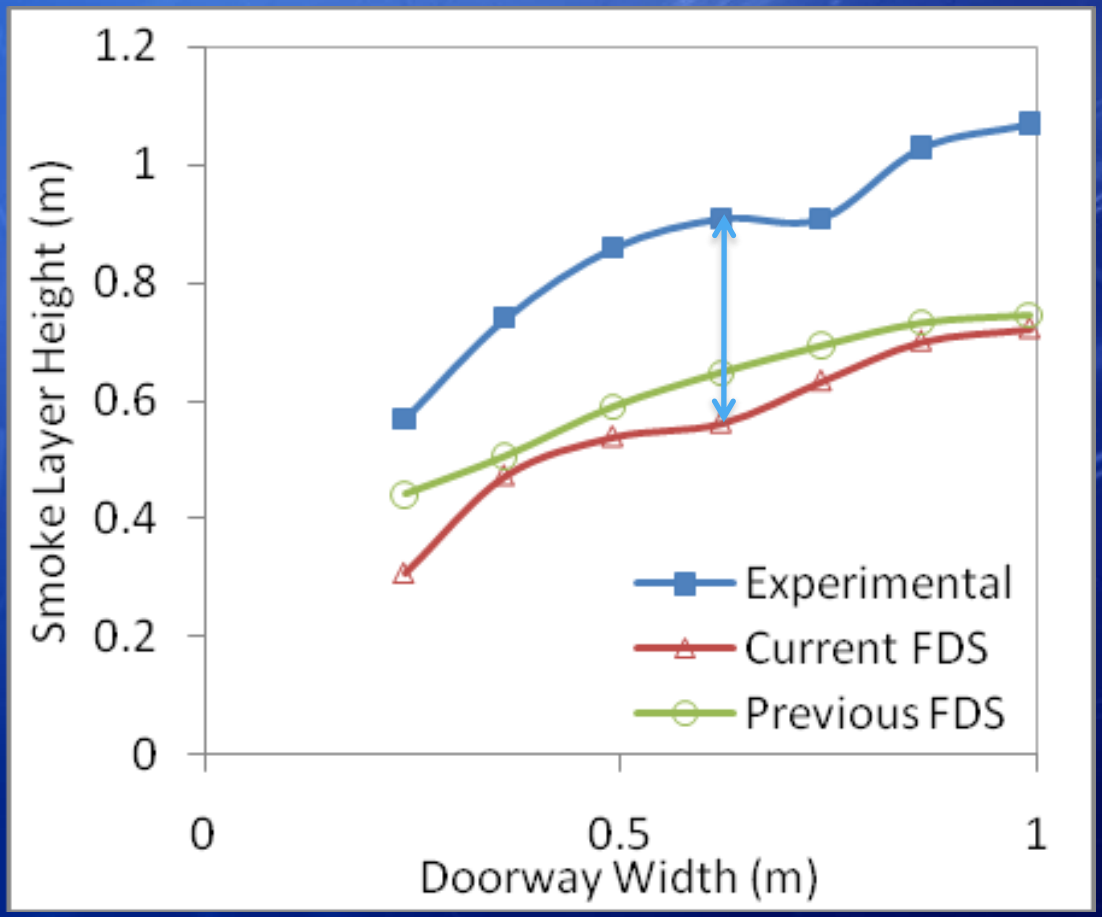
Validations

- Fire Source at Center (Position A) :
  - Neutral plane height



Validations

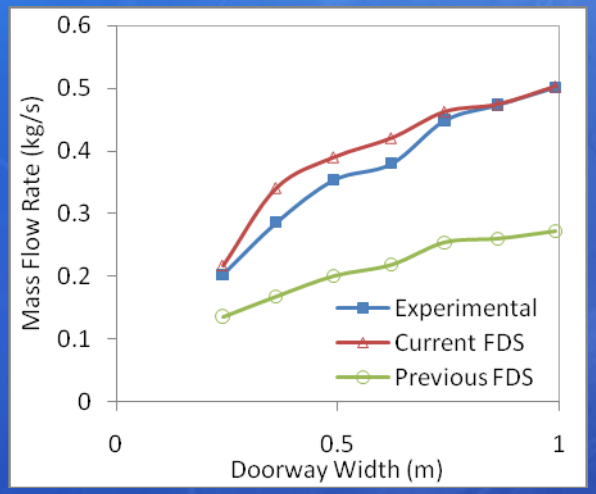
- Fire Source at Center (Position A) :
  - Smoke layer height

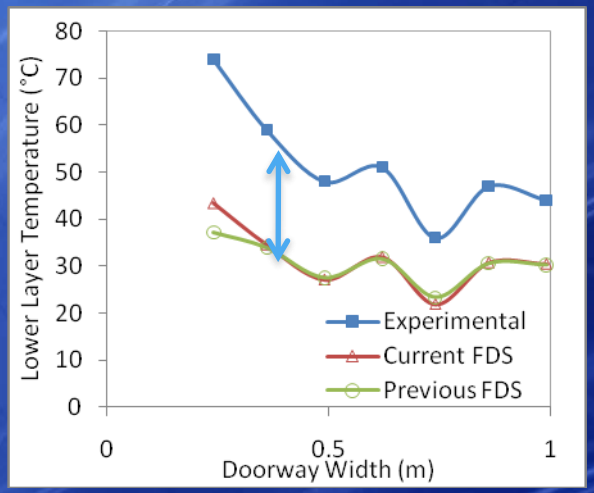


Results and Discussions

- Fire Source at Corner (Position B)

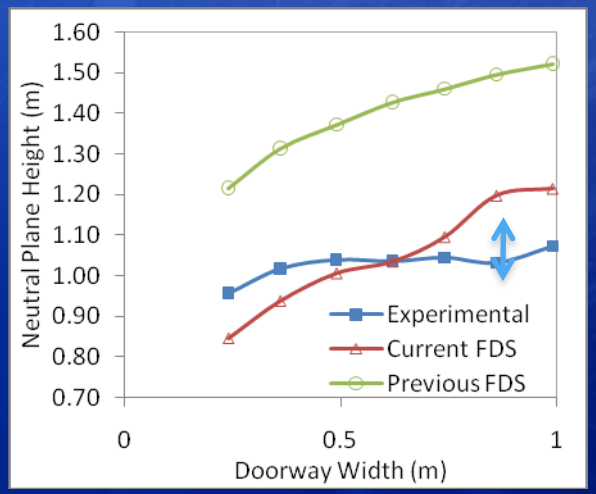
Flow Rate

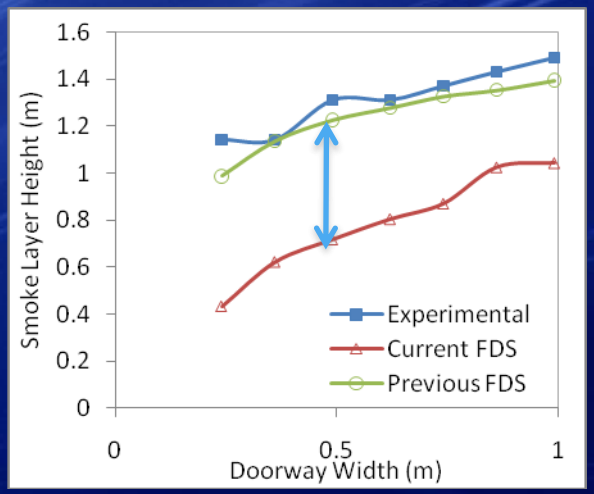




Lower Temp

Neutral

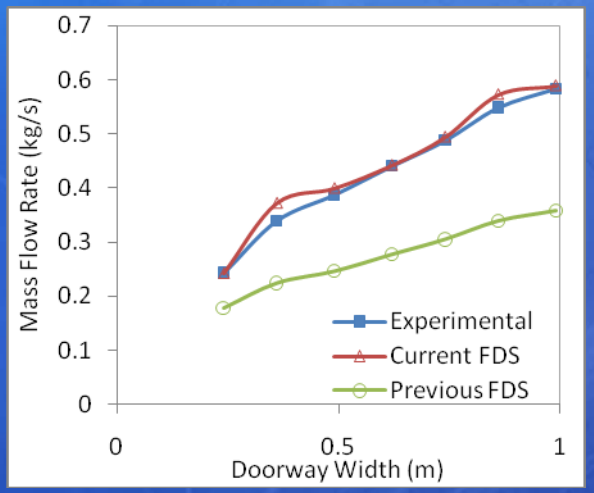


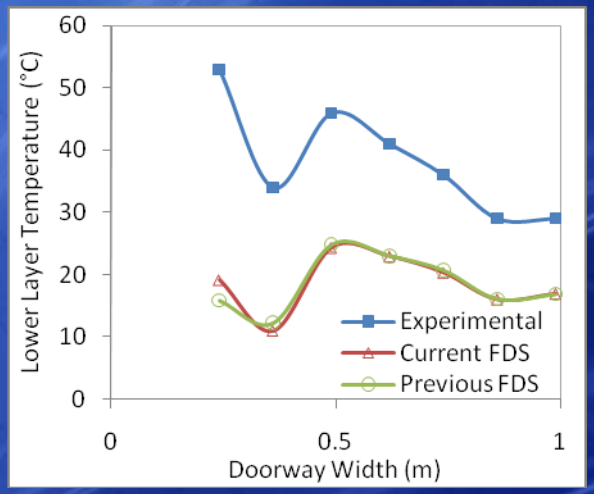


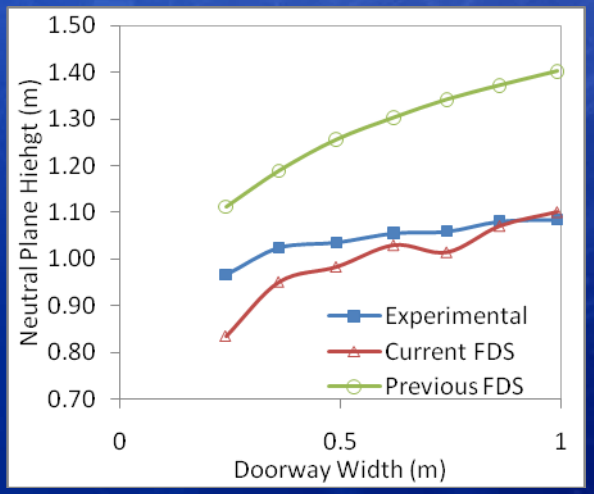
Layer

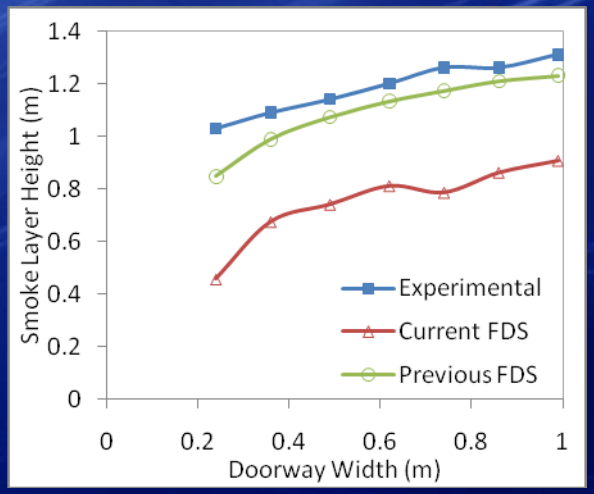
Validations

- Fire Source at Wall (Position C)









Discussion

1. The improvements on model inputs made to the FDS simulation allowed significant improvements to the prediction of mass flow rates for all three positions of the fire source.

2. There is not much improvement for the remaining three parameters being compared: neutral plane height, low layer temperature and smoke layer temperature.

3. Since these three zone-model based parameters are calculated by an integral approximation. It is not advised that they are predicted by using FDS.

Mass flow rate ~ 5 %, Neutral plane +/- 10 %, Layer & Lower *T* – 40 %,

Discussion

Two rules of thumb

A distance of $0.5D_d$ (effective diameter of doorway) from the vent on the computational domain is needed to avoid the possible inaccurate boundary conditions (within 5%).

For fire located at the corner and against the wall, a shifted distance for the burner of $2D_b$ (diameter of burner) is needed to compensate the entrainment loss (within 5%).

Thank You !